Challenge Proposal

# MICCAI-BRATS 2014 - Challenge on Multimodal Brain Tumor Image Segmentation

## 1. Agenda

Because of their unpredictable appearance and shape, segmenting brain tumors from mult-modal imaging data is one of the most challenging tasks in medical image analysis. There is, however, a growing body of literature on computational algorithms addressing this important clinical task, with about 40 new methods published in the past three years alone. Unfortunately, open data sets for designing and testing these algorithms are not currently available, and private data sets differ so widely that it is hard to compare the different segmentation strategies that have been reported so far. Critical factors leading to the large variety in training and test data include the imaging modalities employed (T1 and T2 MRI tissue contrasts, T2 FLAIR and T1 contrast-enhanced MRI, various parametric maps from diffusion or perfusion imaging, or any subset of these); the type of the lesion (primary or secondary tumors, solid or infiltratively growing); and the state of disease (images may not only be acquired prior to treatment, but also afterwards then showing different signs of radio-therapy and cavities from resection).

## 2. Academic Objectives

In order to gauge the current state-of-the-art in automated brain tumor segmentation and compare different methods, we organized “Multimodal Brain Tumor Image Segmentation” (BRATS) MICCAI challenges in 2012 and 2013. As part of this challenge we generated an annotated data set with about 60 low and high grade cases. The data are publicly available from the VSD[1] and the MIDAS[2] web pages, two online platforms for hosting and evaluating image segmentation benchmarks. In 2012 and 2013, altogether 20 groups participated in the challenges, a related journal manuscript that is to be submitted to TMI describing the results of these efforts is in preparation[3].

We want to continue the MICCAI-BRATS challenge in 2014. To this end, we will invite about 10 different research groups (primarily participants from the past challenges) to automatically annotate the MRI data sets of The Cancer Imaging Archive (TCIA, www.cancerimagingarchive.net). The Cancer Imaging Archive features data sets that were acquired prior to and post therapy at two different clinical centers, using an imaging sequence with T1, contrast-enhanced T1, T2, and T2 FLAIR MR images as part of ongoing NIH studies. We will fuse the 5-10 automatic segmentations to have an approximate “truth” for about 200 low and high grade glioma patients (with multiple time points for selected cases). We will manually annotate a subset of the data sets to estimate automated segmentation quality, and correct it (at least for the test data), if necessary. The preprocessed (coregistered, resampled, skull stripped) images will be made available in spring via VSD, complementing the existing training data set from MICCAI-BRATS 2012&2013.

[1] https://vsd.unibe.ch/WebSite/BRATS/Start2013
[2] http://challenge.kitware.com/midas/folder/102
[3] A preliminary version is available here: www.vision.ee.ethz.ch/~bmenze/tmp/brats_manuscript_3.pdf

## 3. Workshop Format

### Image data and evaluation process

All real data will be distributed as co-registered, interpolated to the same resolution (1 mm^3) and skull stripped, a total to 200-500 multimodal volumes from about 200 patients with clinically confirmed diagnosis. Images are acquired before and after therapy. The data will be split into training and test data. Training data will be distributed prior to the conference (about 80% of the data set), whereas test data will be held back for a segmentation contest that will take place shortly before MICCAI within a controlled time window. The test data will be made available via the VSD platform and accepted and registered challenge participants will have a limited time frame (24h, or 48h) for uploading results. We prefer this “off-site” evaluation as we want to process a data set that is larger than in previous years (50+ data sets, rather than 10-15), and experience from the events in 2012 and 2013 showed that 6-10h of an “on-site” evaluation will not be sufficient for many algorithms. The VSD platform will guarantee a controlled evaluation of the test data that is comparable to a conventional MICCAI “on-site” benchmark challenge.

Training data will be available in April/May. Participants have to submit short papers reporting their approach, as well as preliminary results on the training data in July. Submissions will be reviewed by the organizers, and distributed in the workshop proceedings. Results of the “off-site” will be announced at the workshop. A joint journal publication of all participants will be prepared after the workshop.

### Tasks

All participants will be presented with the same test data. We will evaluate three subtasks. Performance scores of task one and two will be evaluated for every submitted segmentation, task three is optional:

1. The general evaluation of a data set of 50+ test volumes, similar to the past years (and including test data of the past years to be able to compare results)
2. The evaluation of longitudinal image sequences representing a subset of these test data. Participants will get the information what image volumes belong to a series and they can consider this for their evaluation, or they can treat the given training and test volumes independently.
3. The global classification of a case into one of the three classes: low grade (II), low grade (III), high grade (IV / glioblastoma). Participants can infer these global labels from their segmentations, or directly from the images without previous segmentations.

For tasks one and two we will use segmentation evaluation metrics as implemented in VSD. We will use the same test cases for the BRATS challenge and the Digital Pathology challenge (see below) to encourage discussions between the different audiences and to compare the diagnostic value for the automated classification of MRI and pathology images.

### Anticipated number of participants

A literature review indicates that there are about 150 publications related to tumor segmentation (not all on glioma) from the past 20 years. We will contact about 40 groups with related publications in the past three years, and also publicize the event through appropriate mailing lists (imageworld, machine-learning, visionlist) and on a dedicated challenge home page.

We expect between five and ten groups to participate as a conservative estimate (2012: 10 participating groups, 2013: 10 participating groups). As we will collaborate with 5-10 groups for annotating the training data, it is very likely that this pool of contributors will also participate in the challenge (leading to 10+ participating groups).

**Workshop Cluster at MICCAI 2014**

If the challenge is accepted, we want to combine MICCAI-BRATS 2014 with two other workshop/challenges into one "**Workshop and Challenge Cluster on Brain Tumor Imaging**" spanning a whole day. Please see the attached schedule that we would anticipate for the joint program of all three events.

We would organize BRATS as a half day event together with the "Brain Tumor Digital Pathology Challenge" (Saltz, Brat, Gilbertson), also dealing with image data from the TCGI repository, and, hence, a patient population identical to our data set. The other half day event should be filled with the "Clinical Decision Support and Precision Medicine in Brain Cancer Workshop" (Farahani, Jaffe, Clark) discussing general aspects of the TGIA repository, including upcoming technologies that combine image interpretation with the analysis of histological and "omics" information.

All three events share the common agenda "to present and discuss requirements and resources for open science development of systems for clinical decision support and precision medicine in brain cancer diagnosis and therapy based on Big Data, including genomics, pathology, and imaging".

We would expect that the whole day cluster event (previous section) would attract at least 10-20 active challenge participants (plus organizers) and also at least the same numbers of general workshop attendees.

## 4. People

**Organizers**

Bjoern Menze
TU Munich, INRIA Sophia-Antipolis
*http://www.ee.ethz.ch/~bmenze*

Jayashree Kalpathy-Cramer
MGH Harvard
*http://www.martinos.org/user/8165*

Keyvan Farahani
National Cancer Institute NIH
*http://imaging.cancer.gov/aboutcip/staffdirectory*

Mauricio Reyes
University of Bern
*http://www.istb.unibe.ch/content/about_us/staff/mauricio_reyesnbspphnbspd/*

# Appendix

## MICCAI 2014 - Workshop and Challenge Cluster on Brain Tumor Imaging

**Goals:** To present and discuss requirements and resources for open science development of systems for clinical decision support and precision medicine in brain cancer diagnosis and therapy based on Big Data, including genomics, pathology, and imaging.

**8:30 am – 12:00 pm Workshop**

**Clinical Decision Support and Precision Medicine in Brain Cancer: The Value of Open Science Grand Challenges**
Chairs: Farahani (NCI), Jaffe (BU & NCI), and Clarke (NCI)

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| 8:45am–10:00 am | Invited talks (3-4) – emphasizing computation and/or path correlation, plus<br>• Report: NCI Workshop on Imaging and Genomics<br>• Open science platforms for assessment of technologies |
| 10:00am–10:30am | Break |
| 10:30am–11:30am | Proffered papers |
| 11:30am–12:00pm | Presentation of NCI resources: TCGA, TCIA, HubZero, etc. |

**1:00 pm – 5:30 pm Brain Tumor Challenges**

**Brain Tumor Image Segmentation Challenge (BRATS)**
Chairs: Menze (TU Munich), Kalpathy-Cramer (MGH), and Reyes (Bern U)

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| 1:00 pm – 1:30 pm | Presentation of results by chairs and discussion of results |
| 1:30 pm – 2:15 pm | Presentations by top 3 challenge winners<br>(12 min each + 3 min discussion) |
| 2:15 pm – 3:00 pm | General discussion |
| 3:00 pm – 3:30 pm | Break |

**Brain Tumor Digital Pathology Challenge**
Chairs: Saltz (Stony Brook) and Brat (Emory) or Gilbertson (MGH)

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| 3:30 pm – 4:30 pm | Presentation of results by chairs and discussion of results<br>(20 min each + discussion) |
| 4:30 pm – 5:15 pm | Presentations by top 3 challenge winners<br>(12 min each + 3 min discussion) |
| 5:15 pm – 5:30 pm | Wrap-up |

**Scientific Committee**: Brat, Clarke, Davis, Farahani, Freymann, Gilbertson, Jaffe, Kalpathy-Cramer, Kurc, Menze, Mercer, Reyes, Saltz